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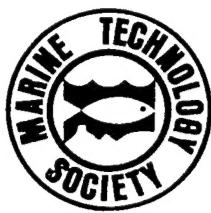
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A MAP SERVER FOR REALTIME HYDROGRAPHIC DATA COLLECTION SYSTEMS

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Introduction

The Oceanographic Remotely Controlled Automaton (ORCA) is a prototype Naval hydrographic / oceanographic survey system operated from a mother ship (Figure 1). Measurements are radioed to a control station on the mother ship, logged, and displayed in real time. A decluttered and customized chart background was needed to expand situational awareness. This paper describes the adaptation of an existing government map application program to provide the needed map services to the ORCA control station.

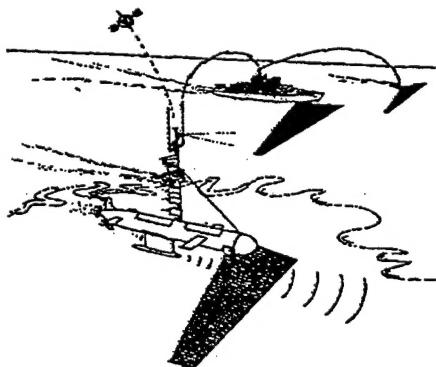


Figure 1. One or more ORCA survey platforms operate in proximity to a mother ship. Survey data is radioed to the mother ship for realtime display.

Many hydrographic surveys are conducted in areas for which charts exist in some form and at some scale, often for the purpose of updating the existing chart or perhaps producing a chart at a larger scale. The ready availability of the pre-existing chart data may provide a valuable aid in the selection of survey platform and equipment and in planning the actual survey tracks, so as to properly investigate suspected navigation hazards such as underwater wrecks and other obstructions.

Vector vs. Raster Charts

The National Imagery and Mapping Agency (NIMA) is nearing completion of a program to convert all

existing paper charts to the Digital Nautical Chart (DNC) product, which is a geo-relational vector database format distributed on CDROM. A single DNC typically contains a number of charts at different scales including general, approach, and harbor charts, all within the same geographic region. A chart display is constructed by querying the DNC database for the geospatial description of the chart features as well as the feature attributes, and then symbolizing the features on the display. Thus the appearance of the chart on the display can be completely controlled by the query and display software. Raster based charts consist more simply as a matrix of pixel color values which are simply moved in bulk to the screen. The display of vector charts is more flexible than raster charts, but with that flexibility comes increased complexity of the display software.

The Chart Server Requirements

The complexity of the process of displaying vector charts noted above brings us around to the need for a reusable chart tool that can be easily integrated into survey systems or any other type of system needing to add a map or chart display. Basic charting requirements include: The chart server must have a complete user interface for configuring the map data content and all other display parameters. This relieves the client program from having to construct this non-trivial interface. The usable chart data products must include not only DNC but also other DOD map data and chart products where DNC is not available. Also required is the capability to scan in a paper chart on an inexpensive scanner, geo-register and use it as well. This requirement makes sure that any and all DOD chart sources can be used. The client program must be able to control the chart projection, location, and chart scale. This puts the client program in control. The client must be able to retrieve chart images from the chart server.

New chart server requirements include: The chart server interface as seen from the client should be very simple to use, requiring only a compiler and a standard sockets library. The chart server must be

able to run on the same computer as the client or a different computer. The chart server interface should be network transparent and interoperable across various type of computers (Windows based or UNIX). The chart server interface should hide all network transport layers and machine architecture differences. The chart server interface should be able to pass data and data structures both ways.

The Chart Server Design

An existing, general purpose mapping and charting application program NIMA Mapping, Charting & Geodesy (MC&G) Utility Software Environment (NIMAMUSE) Fusion V2.1 was chosen as the basis of the chart server. NIMAMUSE is a collection of application software programs produced by NIMA and intended to demonstrate the NIMA digital data products and to interface them to popular commercial software systems. NIMAMUSE application programs, documentation, and even source code may be downloaded by the public from http://www.nima.mil/geospatial/SW_TOOLS/NIMAMUSE.

Fusion V2.1 (2 and 3) as downloaded met all of the basic charting requirements listed above. All that was needed was to add a relatively small amount of code to turn it into a chart server meeting the rest of the requirements. Transmission Control Protocol / Internet Protocol (TCP / IP) Sockets (a commonly used networking software library) was chosen as the basis for developing a simple command protocol. The command protocol layer and the sockets layer are both hidden from the client programmer by means small client side function library that is linked into the client program. The client side library provides an application programming interface of about 85 functions, but usually only a very few are needed for most clients.

A Sample Client Program

The following C language program connects to the chart server, creates a new map, positions it, adds a map graticule and UTM grid, and finally saves and closes the map. Non-programmers may wish to skip this section.

```
#include "mapapi.h"

void main(void)
{
    MAP_ID my_map_id;
    double latitude=30;
    double longitude=-90;
```

```
    double scale_reciprocal=1000000;
    long image_width=400;
    long image_height=400;

    /* Fusion is running on the same computer */
    map_set_host("localhost");

    /* Create a new map named "mymap"*/
    my_map_id = map_file_new("mymap");

    /* Set the map center, scale, and image size */
    map_loc_center_scale_size(my_map_id, latitude,
        longitude, scale_reciprocal, image_width,
        image_height);

    /* Add a map graticule */
    map_data_graticule_add(my_map_id, 0);

    /* Add a UTM grid */
    map_data_grid_add(my_map_id, 0);

    /* Save the map */
    map_file_save(my_map_id);

    /* Close the map */
    map_file_close(my_map_id);
}
```

Client Integration Issues

Issues of chart scale, registration, color, and performance arose while planning the integration of digital charts into the survey system.

Chart scale is the ratio of feature size on the chart to the actual feature size in the world. The ORCA control station display provides virtually infinite zoom capability so that the operator can zoom out for large scale situational awareness, and then zoom in for a large scale look at the data being collected. Digital charts are often not available at the scales (about 1:5000) used for data quality analysis while surveying, and digital charts at significantly smaller scales (less than 1:50,000) proved unusable.

Proper registration of the chart background with the survey data is an important integration issue. Accurate registration requires close congruence in the projection routines on the client and server as small discrepancies in the projection implementations can cause data registration errors. For performance reasons, Fusion does not allow projection selection while using raster charts, resulting in the display of the chart background in one projection and the survey data in another. This miss-registration was best accommodated by setting both the chart and the

survey data displays to the same center point and tolerating slight miss-registration around the edges of the display.

The same software system is used to display both the chart and the survey data and uses only a small number of colors. The Fusion software supports this situation well by re-mapping the chart image into the client's color palette before sending it to the client.

When the user initiates a zoom or pan operation, the chart server must usually load additional data from the digital chart on CDROM, render the chart image, and then transmit it to the client computer, requiring as much as 10 seconds total time. In order to maintain interactive control of the ORCA display and continuous display of the survey data, the chart request and display are performed asynchronously, using separate execution threads for each chart request.

It is quite possible for the user to initiate zoom and pan requests faster than they can be serviced by the Fusion chart server, resulting in a series of chart images being queued up for display, at least some of which are no longer spatially relevant. Since the Fusion server currently offers no feature to cancel a pending chart request, the following steps were taken:

- 1) chart requests are always allowed to complete,
- 2) multiple chart requests are not queued when a request is outstanding,
- 3) only the latest request is kept pending completion of the current request

A sequence of quick requests is effectively converted into two requests (first and last).

At Sea Testing

The operation of the Fusion chart server was tested during the ORCA sea trials near Pensacola, FL in August 1998 (Figure 2). A number of problems arose, but in all cases the problems were resolved through close cooperation between the client and chart server programmers or acceptable workarounds identified.

Proper chart registration was achieved by configuring the Fusion chart server to draw vector based charts on a Universal Transverse Mercator (UTM) projection matching the projection used by the survey data display system.

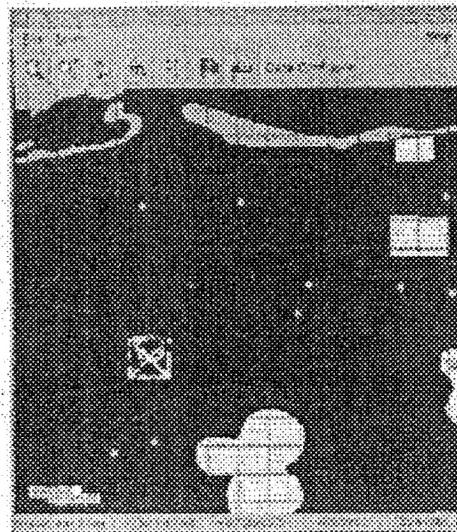


Figure 2. The chart image is customized to support the review of realtime survey data. Depth contours, hazard areas, navigation limits, and aids to navigation are shown on a black water background to facilitate the review of the bathymetry swaths shown near the lower left corner.

Initial performance problems were overcome by revising the client side software to request chart images more efficiently.

The scale issue arose since the DNC 15, Edition 3 used in the sea trials contained no approach or harbor charts for the area. The only chart available within the DNC was a coastal chart at a scale of 1:875,000 which, while useful during transits between survey areas, proved completely unusable at the survey scales of 1:5,000. The workaround for this problem was to omit the chart background entirely when display scale exceeds the chart scale by a factor of 10 or more. The chart reappears automatically when the display is zoomed out to a scale at which the chart becomes usable.

Other system improvements were made in areas of performance, chart content, symbology, and robustness until satisfactory chart appearance and performance were achieved.

Conclusion

The successful sea trial resulted from the government industry partnership between the Naval Research Laboratory and C&C Technologies, with the Fusion chart server work performed by the government and the client side work performed by industry.

Where digital charts are available at suitable scales, the addition of the customized chart background provides valuable awareness of the survey environment.

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